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ADAPTATION IN THE CONTENT OF HIGH SCHOOL SCIENCE

The principle that the needs of society determine the work of the school includes as a corollary the necessity for constant adaptation in the processes of education, since the determining needs of society are undergoing a constant evolution. However, the tendency of teachers, of school administrators, and of the entire educational system, is to oppose change and to crystallize both the subject-matter of the curriculum and the methods of presenting it.

As a result adaptation does not take place smoothly and continuously, but suddenly, with resulting strain and disturbance. The war, which revealed many failures in co-ordinating the work in school with life outside of it, precipitated a period of general reorganization in education. The lessons of the war have emphasized the duty of the school to provide a real training for the responsibilities of citizenship, resting upon broad understanding and intelligent insight. As a result of this pressure, all subjects in the high school curriculum are seeking to justify their continued existence through the contributions which each makes toward training the socially efficient being, the good citizen.

It is not the purpose of this paper to present in a merely academic way the value of science study in training the future citizen of the world for the intelligent discharge of his duties.* Rather, it is the purpose to describe some ways and means which have been used in the class room, laboratory and general life of the school to render science study a vital factor in the lives of the pupils and to secure a larger measure of flexibility in the science courses and a better adaptation to individual interests and needs.

UTILIZING THE MORNING EXERCISE OR SCHOOL ASSEMBLY

Good citizens are active in placing valuable information at the disposal of their fellows. So in school the science classes can do a great deal towards actively sharing ideas and interesting facts with the rest of the school body. This finds a ready response in the general interest shown in scientific phenomena, and the eagerness to understand the demonstrations and explanations. In this school the daily morning exercise* furnishes the best opportunity for efforts of such a nature. Recently the chemistry class gave a series of four exercises. These exercises served to arouse interest in science in general and chemistry in particular; to stimulate pupils to thinking and perhaps experimenting at home and in leisure time; to illustrate the content of the chemistry course and to some extent to encourage pupils to elect science courses another year; to furnish the school with information on important topics.

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*For a more complete summary of the purposes of high school science, see Vol. V, *The Course in Science,* pp. 138-141.

The titles and outlines of these exercises are given in some detail.

I. WATER**

Introduction.—Importance of pure water to civic health and industrial prosperity.

Testing and Purifying Methods Illustrated Experimentally.—Suspended matter by sedimentation and filtration. Mineral salts by distillation, with tests for sulphates, chlorides, etc. Organic matter, including bacteria, by boiling and oxidation with potassium permanganate.

Purification by Coagulation.—Methods used at Columbus, Ohio, illustrated with roily water colored with cochineal.

Relation of Water Supply and Sewage Disposal.—Chicago Drainage Canal an open sewer. Better methods of sewage disposal in use in other cities.

II. CHEMICAL MAGIC

This exercise consisted of a series of spectacular experiments performed in such a way as to mystify the audience and challenge their ability to find a satisfactory explanation. It was gotten up by a small group of the class, more as a chemical vaudeville entertainment than a regular exercise in chemistry.

A variety of indicators and reagents were used to turn water into wine and back again, convert a large jar of apparent ink into clear water, a portion of which was drunk, and to produce other striking color changes. Sympathetic ink was devised and used to predict magically the outcome of an election to be held on the morrow. For this purpose the writing had been done upon large sheets of paper with a solution of

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*For full exposition of the place and function of the Morning Exercise, see Vol. II, *The Morning Exercise as a Socializing Influence.*

**For another morning exercise on this same subject, given verbatim, see Vol. II, *Chemistry of Water*, pp. 84-89.

potassium sulphocyanate. The messages were caused to appear by spraying the paper with a dilute solution of a ferric salt from a fine atomizer.

Explosive soap bubbles were formed by blowing the air through a concealed bottle containing a little gasoline. With the use of a spot light on a darkened stage a striking effect was produced.

An unlighted cigarette was apparently smoked, whereupon the smoke was caused to appear in a large bell jar upon the table. Ammonia and acid fumes, used with a little sleight of hand, accomplished this.

Large round filter papers had been previously treated with a solution of potassium nitrate. These were suspended in proper order and each one was set off with the red hot tip of a file. The letters burned out, spelling the word "Chemistry."

Water, poured into an apparently empty pan, was set on fire. This effect was produced by igniting a concealed cloth saturated with alcohol, by means of a small bit of potassium.

The final trick involved the calling down of "fire from heaven." Red and green fire were ignited by electric spark from a concealed spark coil and at the same time the national emblem dropped across the rear of the stage.

III. EXPLOSIVES

Introduction.—Explosion defined as rapid burning and an explosive as an intimate mixture or combination of oxygen and a fuel.

Gunpowder.—Composition and burning explained. Gun-cotton; composition and burning explained. Comparison of volumes of gases by equal amounts of gunpowder and dynamite illustrated by the use of charts. Meaning of high explosives made clear.

Explosives in Warfare.—T.N.T. as a type of modern high explosive, used in shells.

Motion Picture.—*Farming with Dynamite* (reel loaned by Du Pont de Nemours Company) showing interesting uses of dynamite on the farm.

IV. NITROGEN

Composition of the Air.—Rough analysis performed as an experiment. Calculation of weight of nitrogen in air resting on the roof of the Auditorium immediately over the heads of the audience.

Nitrogen.—Its inertness illustrated by experiment. An essential life-giving element. The nitrogen cycle explained by colored blackboard diagrams.

Problem of Nitrogen Fixation.—Relation to explosives in warfare. Government plants in the United States and their significance for the future welfare of the country.

These outlines show how civic and national problems may be drawn upon to furnish interesting work for a class, and how the ideas of the whole school may be clarified by a suitable morning exercise growing out of such studies.

THE STUDY OF CURRENT SCIENTIFIC EVENTS

During the war the rapid development of all sorts of scientific devices furnished an especially strong motive for the study of current events in the field of applied science. Every member of the science classes was eager to learn all he could about submarines, airplanes, machine guns, gas warfare and so forth, and this interest was by no means confined to the science classes. To take advantage of this desire and of similar interests along other lines, the whole high school was organized into groups, according to their major interests, science, military strategy, war literature, relief work, political developments.*

The science section was so large that further sub-division according to interests was possible. Groups were formed to study aeronautics, gas warfare, submarine construction and warfare, artillery developments, and methods of camouflage. The section met weekly at a regular period to hear reports from these groups, or to listen to outside speakers, of whom we were fortunate to hear a number on interesting topics. These included talks on "The Emergency Fleet Corporation," by a member of that organization; "The Training of an Aviator," by an instructor in that branch of the service; "Lighting and Signaling Devices," by a patent lawyer, and "War Experiences," by a number of returning graduates and friends of the school. The time was never permitted to drag, and usually more reports were ready than could be presented. Questions were numerous and interesting, though often information that would make the answers adequate was lacking. The responsibility for the meetings was readily assumed by the pupils in a way which showed their deep interest. The reports by pupils included the following: History of Aviation; Flying Stunts; Types of Military Planes; Mustard Gas; The Gas Mask; Development of the Machine Gun; Thermit, with demonstration experiments, and many others.

The intense interest in the military aspects of science evaporated with the coming of peace, but the same plan is now being continued for the study of current scientific developments and of the industrial aspects of science. This supplements more closely the work of the physics and chemistry classes, and so provides for a closer articulation of the science of the classroom and laboratory with that of industry and commerce.

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*See the brief article in this volume, *The Study of Current Interests in the High School.*

TOPICS AND PROBLEMS INCLUDED IN THE REGULAR WORK OF THE PHYSICS AND CHEMISTRY CLASSES MAKING FOR FLEXIBILITY

The following list is added to show a great variety of interesting topics which may be drawn upon for illustrative and informational purposes, special assignments, and individual reports. Local conditions, individual interests and needs, and the amount of time available must determine the selection of these topics, their emphasis and their proper organization into the larger units of study. Such a list could be greatly extended; nevertheless, many topics suggested must through necessity be omitted, or only occasionally included.

CHEMISTRY*

Fertilizers.—Problems of soil fertility, elements needed by growing plant and function of each. Photosynthesis and carbon dioxide cycle. Nitrogen cycle and function of nitrogen fertilizers. Potash, a German monopoly until war forced American chemists to search and find new sources. Use of limestone and phosphate rock.

Artificial Stone.—Limestone and its derivatives, lime, mortar, and plaster. Portland cement, its manufacture from natural marls, from slag of the blast-furnace. Excursions to lime kiln and cement mills. Cement construction, its great possibilities. Concrete and stucco. Gypsum and Plaster of Paris. Clay products, brick, pottery, chinaware, and porcelain.

Glass.—Crown, flint, and lead varieties. Special glasses for chemical ware of low coefficients of expansion. Coloring glass, with borax beads as illustrations.

Coal.—Composition and fuel values of different varieties. Heat units as a basis for purchase. Distillation products: coal tar, ammonia, coke, and gas. Derivatives of coal tar: light, middle, and heavy oil, tar, pitch. Relation to dyes, explosives, and drugs.

Petroleum.—Fractional distillation into burning oils, solvent oils, lubricants, paraffins. The automobile and the gasoline supply. Oil shales as a possible source of future supplies.

Wood.—Distillation of wood to produce methyl alcohol, acetone, acetic acid, charcoal. Print paper as made from wood.

Explosives.—Black powder, nitro-glycerine, dynamite, gun-cotton, trinitro-toluene. Relation to nitrogen fixation by the arc, Haber, and cyanide processes.

Paint, Varnish, Etc.—Paint oils and driers, varnish, shellac, copal. Linseed oil, oil cloth and linoleum. Pigments, white lead, red lead, iron oxide, lead chromate.

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*For a fuller treatment of these and similar topics, see Vol. IV, *Some Laboratory Experiments Involving Real Chemical Problems*, pp. 119-125, and Vol. V, *The Course in Science, Chemistry*, pp. 160-168.

Cleansing Agents.—By acids; oxalic and hydrochloric. By alkalies; caustic soda, soap, emulsification. By solvents; carbon tetra-chloride, benzine. Spot and stain removal. Composition of trade-marked cleaning fluids.

Foods.—Sugar: preparation and refining of beet and cane varieties, conversion to caramel, inversion. Starch: manufacture from corn, cooking to dextrin and paste, hydrolysis to glucose. Fats: olive oil, cottonseed oil, butter, oleomargarine. Hardening oils by hydrogenation with nickel as a catalizer.

Beverages.—Charged waters: soda, mineral. Infusions: tea, chocolate, coffee. Fruit juices and fermentation. Industrial and denatured alcohol.

Dyeing.—Direct and mordant.

Matches.—Phosphorus and safety types.

Photography.—Chemistry of blue prints, plates, films, prints, toning, etc.

Adhesives.—Gums, paste, dextrin, glue.

Inks.—Various kinds.

Abrasives.—Carborundum, emery, alundum, metal polishes.

Refuse Disposal.—Sewerage and garbage. Fermentation and putrefaction. Civic problems. Disinfectants and deodorizing agents.

Preserving.—Sterilizing, pasteurizing, drying, pickling by salt and sugar. Chemical preservatives and tests for them. Administration of Food and Drug Laws, state and national.

PHYSICS

The list of physics is brief, only larger topics and problems for class study being given, without elaboration:

How the government protects the public from fraudulent weights and measures and dishonest practices. The work of the city sealer.

Heating and Ventilation in School and Home
The Work of the Weather Bureau
Municipal Lighting
Class study of familiar machines and devices: the victrola, bicycle, automobile, camera, vacuum cleaner, electric toaster, etc.
Water Wheels and their Development
White Coal and Conservation of Forests
Cold Storage and Artificial Ice
The Street Car System
The Water Works and Fire Prevention
The Submarine and Deep Diving Apparatus
Newspaper Printing
Electro-plating and Electro-typing
Three and Four Color Printing
The Telephone and the Central Exchange

Wireless Telegraphy* and the Wireless Telephone
The Development of Electric Lighting

Such topics as these are not new in courses in physics and chemistry, but the emphasis on them and the number of them should be greatly increased if science study is to have that quality of reality essential to educative activity. Courses of study in science have a marked tendency to crystallize into a static state. This is perhaps due to the nature of science material, which lends itself to easy classification and organization. There is ever the danger that the teacher, content with teaching the system, the classification, may miss the vital connections by which the facts of science become significant and full of meaning to the pupil.

Successful science teaching in the changing world of today requires a flexible course of study, the use of a wide range of projects, problems, and applications, making possible a closer adaptation to local conditions and individual interests and needs. Teachers of science have failed to keep the content of their courses up to date; they have lost contact with the latest discoveries and applications in which the pupils are often most interested. These faults must be corrected if science study is to accomplish its great purpose and become as vital in the life of the school as it is in the life outside.

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*Just prior to the war a number of high school boys organized and equipped a very successful Wireless Club. A small building on the school grounds was assigned to their use. This was thoroughly overhauled by the boys and an excellent set of instruments had just been installed when the government closed all amateur stations. The apparatus was donated to the school upon the graduation of most of the club members a year ago. A new club has now been formed by the boys of the physics class to carry on the study of this project. It is open, under certain conditions, to other high school boys.